# Ratio solutions for the Gravitation Law.

Recall from math relationships:

- if $\mathbf{a \propto b}$ → then $\mathbf{\frac{a_2}{a_1} = \frac{b_2}{b_1}}$
- if $\mathbf{x \propto \frac{1}{y}}$ →then $\mathbf{\frac{x_2}{x_1} = \frac{y_1}{y_2}}$

Therefore,in a two-planet system:

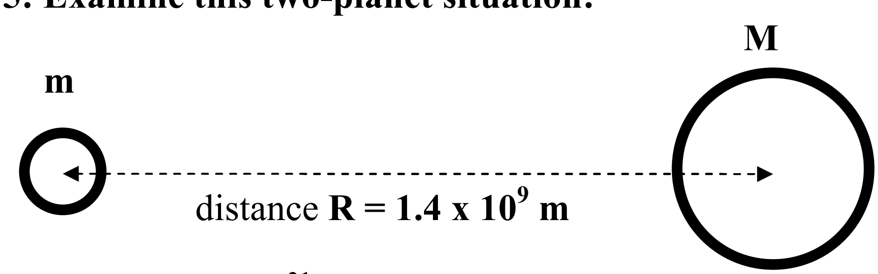
$$\mathbf{F = G\frac{Mm}{R^2}} \quad \text{becomes} \quad \mathbf{\frac{F_B}{F_A} = (\frac{M_B}{M_A})(\frac{m_B}{m_A})(\frac{R_A^2}{R_B^2})}$$

→ or, $\mathbf{F_B = F_A(\frac{M_B}{M_A})(\frac{m_B}{m_A})(\frac{R_A^2}{R_B^2})}$

This appears complex, but is in fact based on some very simple math principles:

- if one mass changes, the force changes proportionally; e.g., if the mass of *one* of the two planet doubles, so does the $\mathbf{F_g}$ between them.
- if <u>both</u> masses change, the force changes proportionally for each mass; e.g., if the mass of *both* planets double, the $\mathbf{F_g}$ between them increases by **2 x 2 = 4** times
- if the distance between the two planets changes, the force between them *decreases* by that factor squared; e.g., if the distance between the planets doubles, the $\mathbf{F_g}$ between them is decreased to $\mathbf{(\frac{1}{2})^2 = \frac{1}{4}}$

**Example 5: Examine this two-planet situation:**




$\mathbf{F_g = 4.1 \times 10^{21}\ N}$ between the two planets

**The above is now changed, as follows; find the new gravitational force in each case:**

**(a) m is tripled.**
**(b) M is tripled, and m is reduced by half.**
**(c) M is one-tenth as large, and R is tripled.**
**(d) m is quadrupled, and R = 9.5 x 10$^8$ m.**

**(see Gravitation Ex 5 for answer)**